OPERATIONS MANUAL

NANOSERIES® ENCODER TEST BOX & INTERFACE SOFTWARE

INTRODUCTION & DEFINITIONS

The Encoder Test Box provides a test interface to the BEI Precision's nanoSeries® absolute optical encoders. By using the Encoder Test Box with a PC running the Encoder Interface Software, the end-user can calibrate, test, and evaluate all nanoSeries® encoders: AIME-II, ARA, TRACKER, & MKE.

PANEL INDICATORS & CONNECTIONS

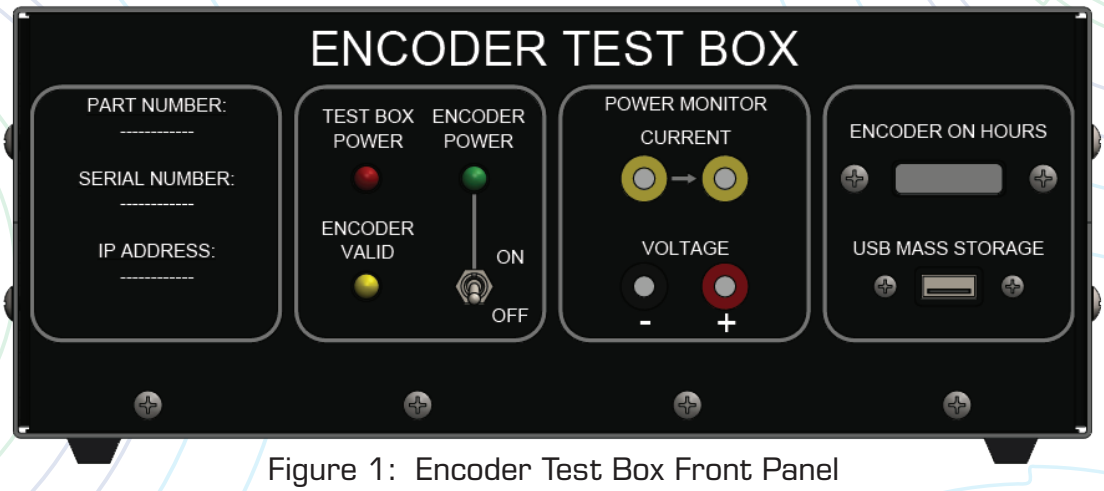

Figure 1: Encoder Test Box Front Panel

TEST BOX POWER: Illuminates RED when the Encoder Test Box power switch is in the ON position. The power switch is located on the rear of the test box.

ENCODER POWER: Illuminates GREEN when the ENCODER POWER switch is on. This light will turn off if the encoder power supply is in a current limit condition for 5VDC (2.5 A); 24 VDC (0.75 A); or external power supply (2.0 A). Over-current of external encoder power will disconnect the encoder from the power supply.

ENCODER VALID: Continuously blinks YELLOW for several seconds when the Encoder Test Box is first powered on, indicating it is booting up. After completing boot up sequence, LED turns OFF. Illuminates YELLOW when the ENCODER POWER switch is on and encoder data is valid. If ENCODER POWER switch is on and ENCODER VALID light is off, this signifies a WARNING for invalid data due to any reason, such as bad or missing data, invalid checksums, etc.

CURRENT: Yellow banana jacks require a jumper or series current meter to complete the power supply circuit to the encoder.

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VOLTAGE: Red (+) and black (-) banana jacks may be used to monitor power supply voltage to the encoder. If a host interface cable is used that has significant voltage drop, a voltage reading may be necessary closer to the encoder electronics.

USB MASS STORAGE: Optional data logging port. This port is not currently enabled.

ENCODER ON HOURS: Accumulates time in hours while ENCODER POWER switch is on and power is successfully supplied to the encoder.

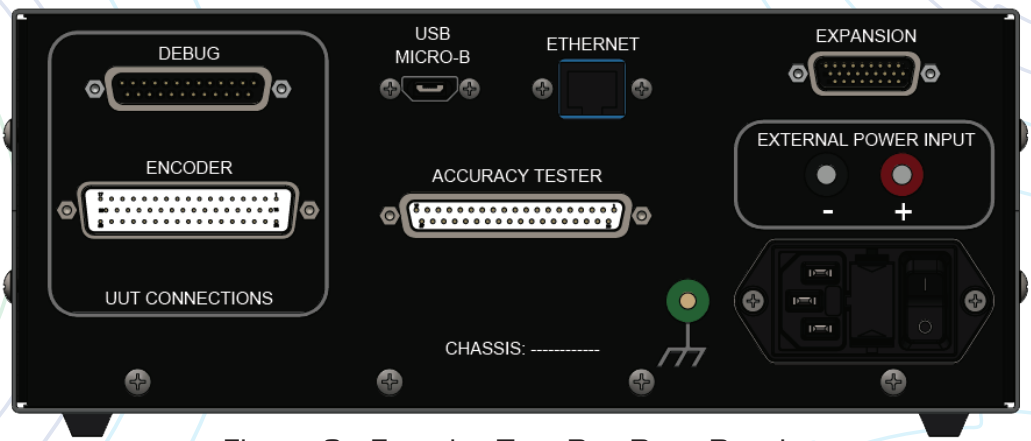

Figure 2: Encoder Test Box Rear Panel

POWER MODULE: (lower right) AC power cord attachment, fuse, and Encoder Test Box on/off switch.

EXTERNAL POWER INPUT: Depending on the power option chosen, encoder power comes from internally generated 5VDC, 24VDC, or a customer generated external power source. External Power is only available if this option is wired in the encoder test interface cable. If this is wired, external encoder power in the range of +5VDC to +36VDC may be supplied to the encoder on the External Power Input banana plugs.

CHASSIS GROUND: May be used to connect the Encoder Test Box to Earth ground.

USB MICRO-B: This is a debug interface to program or debug certain encoders. There is no end-user available access to this port.

ETHERNET: Ethernet connection to a PC running the Test Box User Interface Software.

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UUT CONNECTIONS

ENCODER: This connector is used to interface to the nanoSeries® encoder. Each Test Interface Kit will be supplied with an interface cable that will provide the correct interface from the Encoder Test Box connector to the encoder.

ACCURACY TESTER: 32 bit parallel encoder position output: MSB (180 degrees) on pin 1, LSB on pin 32, data strobe on pin 33 (low to high transition on valid data), pins 34 to 37 are signal ground.

EXPANSION: BEI Precision proprietary interface used for additional customer specific functions.

DEBUG: BEI Precision proprietary interface.

OPERATION

Connecting the Encoder Test Box to a Computer

1. Attach an Ethernet cable from a Windows based PC to the ETHERNET connector on the back of the Encoder Test Box
2. Attach an AC power cable to the Encoder Test Box and connect to clean AC power.
3. Leave unconnected DEBUG, ACCURACY TESTER, USB-Micro B, and EXPANSION on rear panel and USB MASS STORAGE on the front panel.
4. Attach a jumper between the two yellow CURRENT jacks on front panel.
5. Optional: Use a series current meter in place of the current jumper to monitor encoder current draw.
6. Optional: Attach a volt meter between the red and black VOLTAGE jacks on the front panel to monitor encoder power supply voltage.
7. Optional External Power: If the External Power option was ordered, connect an external power source to the EXTERNAL POWER INPUT. Typically there is ~0.3 Volts of drop from the EXTERNAL POWER INPUT to the VOLTAGE reading on the front of the test box. Adjust the external power source to accommodate. Consult BEI Precision for further information.

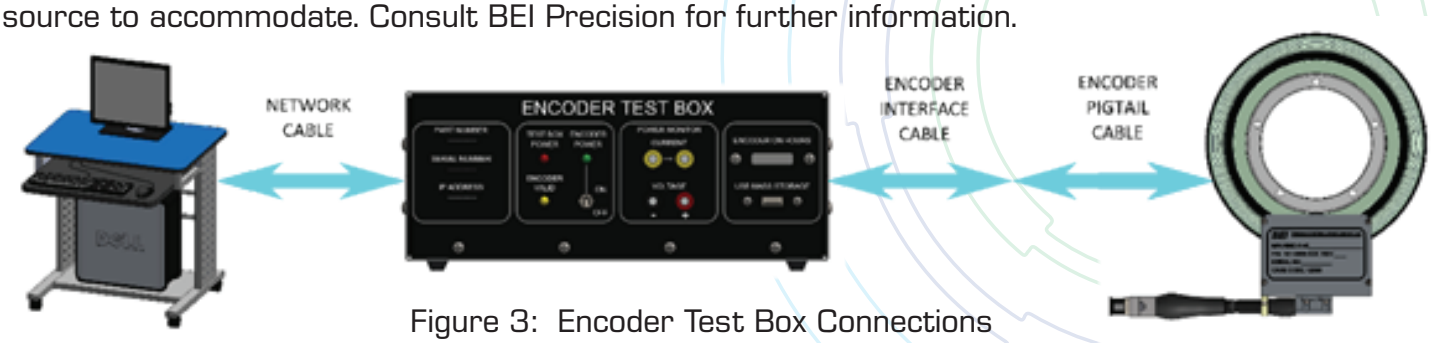

Figure 3: Encoder Test Box Connections

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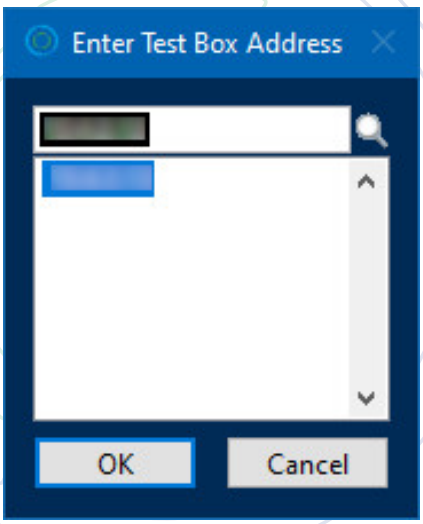
INSTALLING THE ENCODER INTERFACE SOFTWARE

If the software has not been installed on the PC, perform the following steps:

1. Insert the media containing the 300-0639 Encoder Interface Software into the computer.
2. Navigate to the appropriate media drive on the computer.
3. Navigate to folder 300-0639.
4. Double click on the 'setup.exe' file.
5. The Encoder Interface Software will install.
6. A shortcut will be placed on the computer desktop labeled '300-0639.exe Encoder Interface Software.'

Starting the Program & Connecting to the Encoder

1. Power up the Encoder Test Box (power switch on rear panel) and computer.
2. Wait for the yellow blinking light on the Encoder Test Box to stop blinking.
3. Install the encoder readhead & code disk/hub assembly per the encoder ICD.
4. Attach the encoder interface cable supplied with the encoder test box to the ENCODER connection on the back of the Encoder Test Box.
5. Attach the encoder interface cable to the encoder.
6. Flip the ENCODER POWER switch on the Encoder Test Box to the ON position.
7. Rotate the encoder disk/hub assembly at a speed of approximately 1 RPM.
8. Run the 300-0639 Encoder Interface Software on the computer.
9. After the Encoder Interface Software opens, select Connect in the top left corner of the screen.
10. Enter the Encoder Test Box IP address found on the front of the Encoder Test Box and select OK.



11. The Encoder Interface Software will then notify the user of the current test box configuration.

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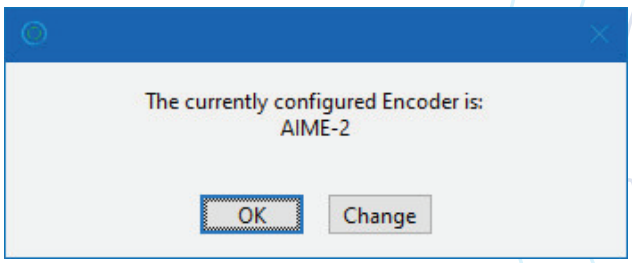
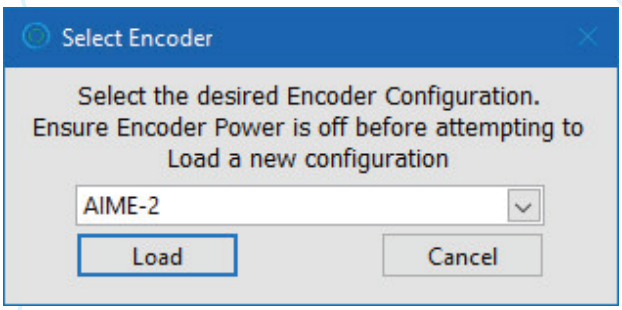
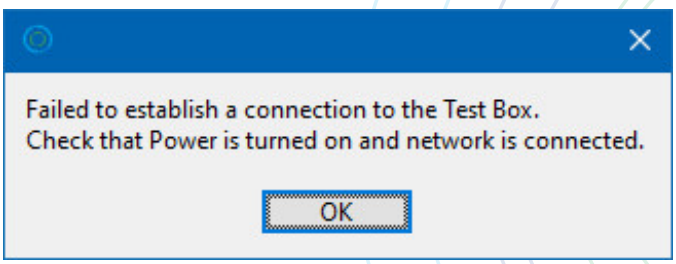


12. If the current configuration is correct, select OK. If required, turn ENCODER POWER (on the front of the test box) off and select Change to change configuration for your encoder. Once the correct configuration is loaded, turn ENCODER POWER back on.



13. After successful connection to the test box with the encoder powered on, the Encoder Interface Software should begin populating data fields/graphs and displaying the current position. Calibration of the encoder might be required to display the appropriate position and merge margins. Calibration is necessary after centering the code disk or if the encoder is assembled for the first time on a spindle

14. If the Encoder Test Box connection cannot be made (due to incorrect IP address or loss of power), the following pop-up will appear.



Select OK and verify IP address, text box power, and network connection to retry.

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Figure 4: AIME- II Normal Mode Interface (same for ARA)

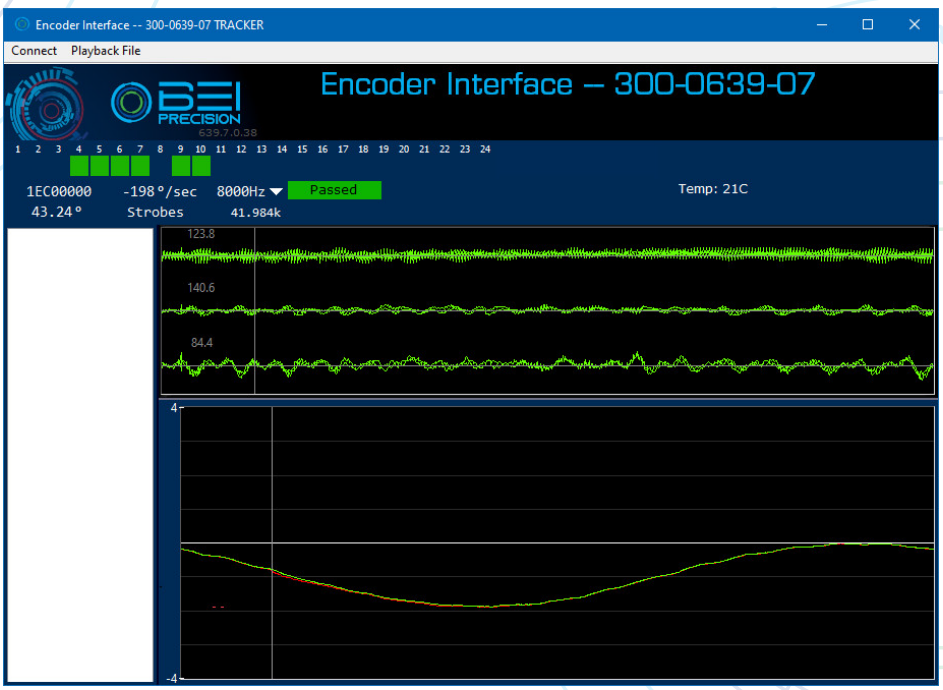

Figure 5: TRACKER Normal Mode Interface (same for MKE)

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USER INTERFACE

The Encoder Interface Software allows the user to generate commands for the encoder and to receive and observe position, status, merge, and alignment data from the encoder. Communications between the encoder and Encoder Test Box is via the Customer Interface serial protocol (see MM-248 AIME-II Communication Protocol or MM-253 TRACKER SPI Communication Protocol). The communication between the PC and Encoder Test Box is implemented with a network connection.

POSITION DISPLAY SCREEN

Encoder position bits 1 (MSB) through 28 are labeled beneath the BEI Precision Logo. The value of each position bit is shown below the bit labels as green (1) or blue (0). The number of bits reported depends on the encoder model.

The following diagram indicates a binary position of 1110 0111 1101 0000 1001 0001 0001 0000. Below this from left to right are the hex position of E7D09010 and rotation rate of 15.3 °/s. The line below the hex position displays the angle in degrees, 326.0°.

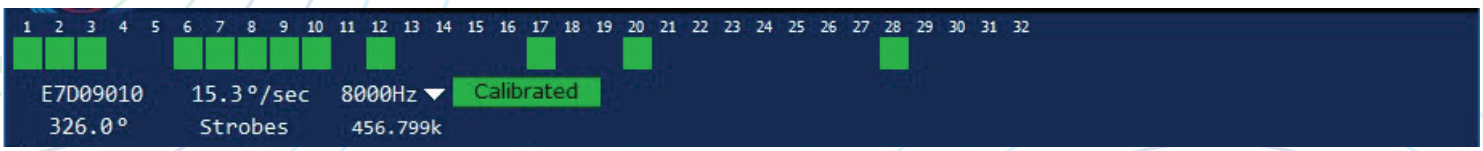

Figure 6: Position Display

SETTING THE ENCODER STROBE RATE

The currently selected strobe rate is displayed to the left of the encoder state in the figure below. Open the Strobe Rate Menu by clicking on the down arrow symbol. It will appear as shown in the figure to the right.

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Figure 7: Active Strobe Rate

Click the down arrow next to the strobe rate indicator.

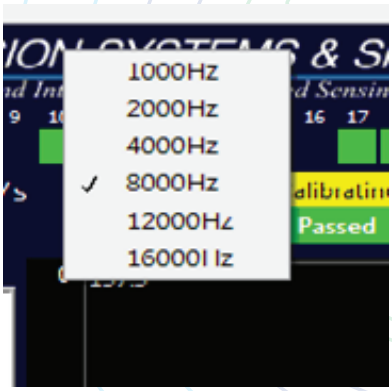

Figure 8: Select Strobe Rate

Select and click on the desired strobe rate.

Note: Refer to your encoder specifications for operational strobe rates and appropriate rotation rates to support calibration. Calibration or operation of encoders at strobe rates exceeding an encoder's specified rate may result in miscalculation of the calibration constants.

SENDING COMMANDS TO THE ENCODER

The command set appears at the left hand side of the display, with the default command as Normal. To issue a command to the encoder, single click on the name of the command.

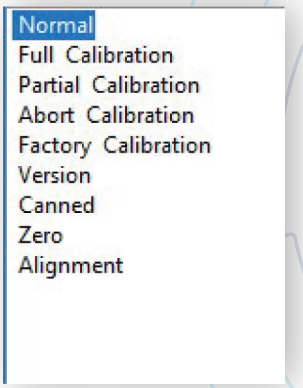

Figure 9: Command Set

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FULL CALIBRATION

BEI Precision's nanoSeries® encoders utilize a proprietary Auto-Calibration scheme in order to obtain maximum accuracy. Auto-Calibration compensates for repeatable error sources to ensure that the encoder is providing accurate position readings. A change in loading on the shaft of the end-user's spindle assembly can cause slight alignment errors between the encoder readhead and code disk. BEI Precision recommends that Auto-Calibration be performed after a significant load change on the encoder's mounting interfaces or any time an encoder is mounted. Auto-Calibrations at regular intervals are encouraged, but not required, to maintain the best possible performance.

Selecting the Full Calibration command will cause the encoder to perform a calibration over a full 360° of rotation. The display will indicate the Calibrating mode and the calibration stage from 0 through 5 (depending on encoder), although all stages may not be noticed as some stages complete rapidly. The user must select the Normal command to return to normal mode after calibration completes. The Normal command can be selected before calibration is over, or after; the encoder will only calibrate once until the user returns to Full Calibration from a different state again. The calibration display is common between encoder types. AIME-II completes calibration in 1 revolution, TRACKER & MKE complete calibration in 3 revolutions, and ARA completes calibration in 4 revolutions. Note that ARA must be strobed at 4000 Hz or less during calibration.

Figure 10: AIME-II Encoder Calibrating (same for ARA)

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Figure 11: AIME-II Encoder Successful Calibration (same for ARA)

If the encoder is rotating too fast (>2 RPM in some cases) or not at all, calibration cannot be completed. If the encoder cannot calibrate for any reason, the encoder will return a status bit indicating a failed calibration, and a Calibration Failure message will be displayed below the current encoder status. After verifying an appropriate rotation rate, ensure the following to allow for successful calibration:

- Code disk surface must be free of debris
- No errors throughout a full rotation
- Alignment of readhead and code disk centering must be within ±0.004 in. (±0.1 mm) in the radial direction; e.g., if the readhead is too close to the axis of rotation resulting in part of the Alignment data to fall off of the alignment visualization screen due to runout, further alignment needs to take place

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Figure 12: AIME-II Failed Calibration (same for ARA)

PARTIAL CALIBRATION

Selecting this function will cause a limited angular range calibration to initialize. The display will indicate the Calibrating mode and the calibration stages from 0 through 5 (depending on encoder). Performing a partial calibration optimizes the accuracy over the chosen range. Calibration outside of the limited angular range will not be optimal, and use of this range should be avoided.

Partial calibration requires two or more complete sweeps between and including the minimum and maximum limits of the end-user's desired range of operation. For AIME-II and ARA, the minimum angular sweep is 10 degrees. For TRACKER & MKE, the minimum angular sweep is 22.5 degrees. For ARA, TRACKER, & MKE, the desired partial calibration range must be pre-programmed at the factory. AIME-II automatically detects the range based on the provided motion.

After successful completion of the partial calibration, the display will indicate a successful calibration, just as in a full calibration. The encoder will continue to return status to the test box,

but will not start another calibration. The user must select the Normal command to return to Normal mode after calibration completes.

ABORT CALIBRATION

Selecting this command will cause any in-process calibration to be aborted. The display will indicate a Calibration Failure until a Normal command is sent. If the display indicates that calibration completed successfully, then the Abort Calibration command was sent too late in the calibration process. If a calibrated is aborted, the previous calibration coefficients are used.

FACTORY CALIBRATION

The Factory Calibration command will cause the encoder to set a flag indicating that calibration is no longer valid. The encoder will keep the latest calibration constants, but will not perform normal absolute encoder merge operations. The encoder will rely solely on the fundamental track, much like an incremental encoder. The display will simply indicate Uncalibrated as shown below. Factory Calibration is a temporary state that is cleared by performing a calibration or power cycle.

Figure 13: AIME-II Factory Calibration Command (same for ARA)

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ZERO

The Zero command will cause the encoder to adjust its zero degree point to the current mechanical position and cause the display to indicate Calibrating – Stage 0, and then Calibrating- Passed. This can be verified by noting the position displays and the current position indicator on the merge margin plots. The Normal function will need to be selected to clear the status indicators.

ALIGNMENT (AIME-II / ARA SPECIFIC)

Selecting the Alignment command places the encoder into two-axis Alignment Mode. Alignment Mode replaces the merge margin and status data in the output stream with data from the on-board tangential and radial sensors. The user interface now displays the Alignment Visualization Tool. This tool displays the Alignment Lissajous, shown in the figure below, plotted on a ±0.004 in. (±0.1 mm) square Cartesian grid. When an eccentrically mounted code disk rotates through one revolution, the radial (vertical axis) and tangential (horizontal axis) data form orthogonal sinusoids. Thus, the Lissajous forms a circle with its radius representing the peak disk centering error and its center representing the readhead to axis of rotation alignment error. The Lissajous below shows approximately 0.5 thousandths of an inch (0.013 mm) of disk centering error, 1.25 thousandths of an inch (0.032 mm) of readhead alignment error towards the axis of rotation, and 0.5 thousandths of an inch (0.013 mm) of readhead alignment error to the right of the axis of rotation. See MM-247 nanoSeries® ARA – AIME-II Alignment Mode technical bulletin for further information.

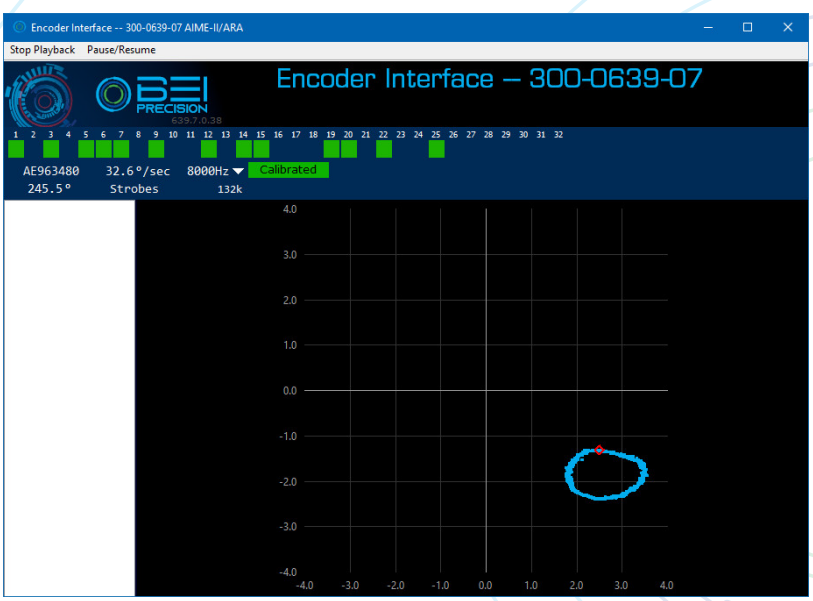

Figure 14: AIME-II Alignment Mode (same for ARA)

ALIGNMENT (TRACKER & MKE SPECIFIC)

Selecting the Alignment command places the encoder into single-axis Alignment Mode. Alignment mode replaces the least significant 14 bits of the position data in the output stream with data from the on-board radial sensor. The user interface now displays the active radial sensor output below the merge margin plots. A sinusoid will be plotted that represents the readhead to code disk radial alignment error. When an eccentrically mounted code disk rotates through one revolution, the pattern moves towards and away from the readhead to create the sinusoidal shape. Alignment Mode can be used to align the encoder readhead to the correct radius, center the code disk, and monitor shaft runout changes throughout mission life. The radial sensor output shown below (Fig. 16) indicate a code disk with approximately 0.5 thousandths of an inch (0.013 mm) peak runout and a readhead that is 2.0 thousandths of an inch (0.051 mm) too close to the axis of rotation. The y-axis radial alignment error range is ±0.004 in. (±0.1 mm). This range includes auto-scaling and is editable by clicking on the limits and typing in a value. See MM-252 nanoSeries® TRACKER Alignment Mode technical bulletin for further information.

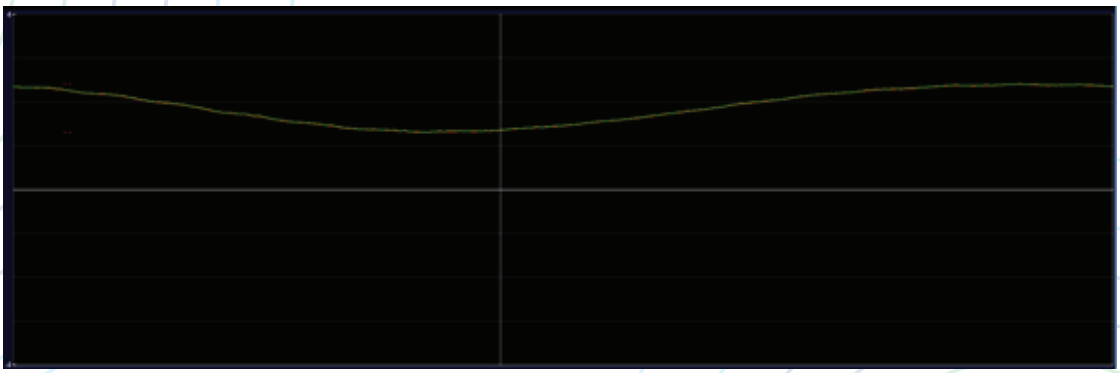

Figure 15: TRACKER (or MKE) Alignment Mode

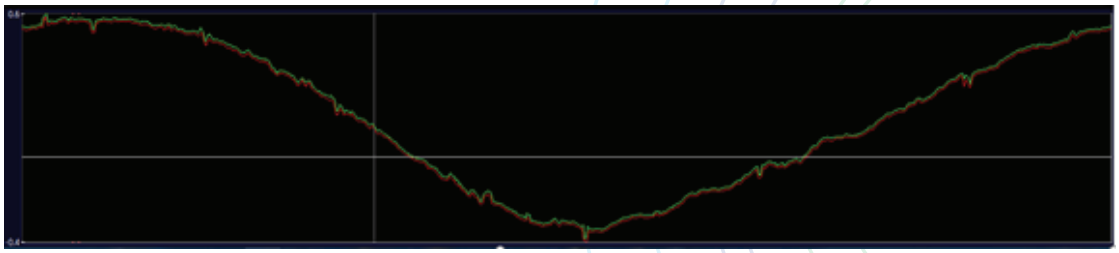

Figure 16: TRACKER (or MKE) Alignment Mode Scaled to -0.4 to 0.6 thousandths of an inch (-0.01 to 0.015 mm)

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VERSION

The Version command will send a request for the encoder to output its software version number. The display will indicate a Forced Output overlay on the binary display, the Version ID number (in this case, 06450200) will be displayed in hex in the position field. The display will remain in this state until the Normal command is selected.

Figure 17: TRACKER Version Command

CANNED

The Canned command will send a request to the encoder to send a fixed position output for communications verification. The display will indicate a Non-Position Output overlay on the binary display. The hex display should indicate 31415927 (for ARA & AIME-II) or 31415900 (for TRACKER) – the digits should always be that of π. The display will remain in this state until a Normal command is selected.

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MERGE MARGIN DISPLAY

The merge margins are an indication of the health of the encoder. The Encoder Interface Software provides three plots that display the merge margins plotted against the encoder position. Only two plots are populated for MKE. The y-axis indicates the merge margins, which range from 180 degrees of margin in the center (perfect merge) to 0 degrees of margin at the top and bottom (failed merge). The number shown in the upper left corner of each graph is the worst merge margin for what is currently displayed. This will update each time a worse margin is detected or the plot is redrawn. If a merge margin displays yellow, a recalibration of the encoder is recommended. If the merge margin displays red, a recalibration is required to ensure that the encoder position is correct.

- Green indicates good merges (close to center)
- Yellow indicates marginal merges (above or below center)
- Red indicates likely failure (close to top or bottom)

Regarding merge margins, outliers matter. Even a single point in the red region is a cause for concern. Outliers could be caused by electrical noise or debris on the code disk. More information on merge margins can be found in MM-254 TRACKER Merge Margin Interpretation.

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MM-259 Rev C 04/21

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Figure 18: AIME-II Merge Margins (same for ARA)

STATUS INDICATORS

Figure 19: Status Indicators

PARITY ERROR

If the test box receives a position word with bad parity or CRC, the Parity error status bit is set and the test box displays Parity N, where N is the error count. Parity errors will often appear upon powering an encoder when the Interface Software is already connected to the Encoder Test

Box. This error can be ignored and cleared (by clicking on it), as it is an artifact of the encoder boot process.

COMMAND ERROR

If the encoder receives a command that it does not recognize, the Command error status bit is set and the box displays Command N, where N is the error count. The encoder will not execute commands with bad parity.

ANALOG FAULT

If the encoder detects a problem with analog signals, the analog error status bit is set and the test box displays Analog N, where N is the error count. May display as Analog, AGCFail, SigFail (AIME II only), or NormFail (AIME II only).

DIGITAL FAULT

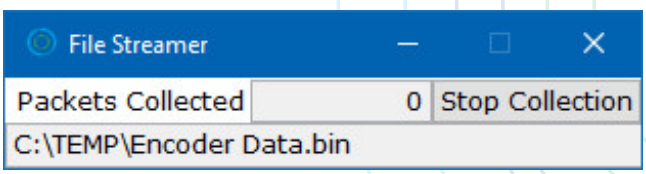
If the encoder detects a problem with communications between the encoder and its analog to digital converters, the digital error status bit is set and the test box displays Digital N, where N is the error count.

DATA COLLECTION AND PLAYBACK

The test box has the ability to record and play back encoder data. A packet of data collected from the encoder per strobe consists of the command sent to the encoder and the complete encoder response.

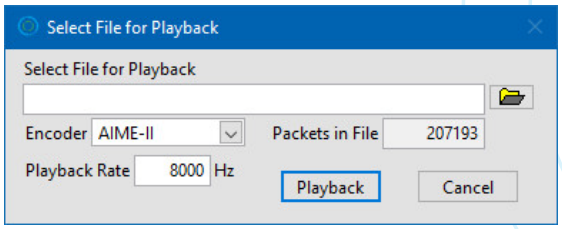
Select Save to File to save encoder data. A path screen will pop up. Navigate to the desired directory and select or enter a file name. Live encoder data will be streamed to the chosen file.

The following pop-up will display showing the number of data packets saved to the file. Clicking Stop Collection will cease data collection and close out the file.



To play back the file, select Disconnect from the Test Box. When disconnected, you have the option to choose either Connect or Playback File.

A popup appears prompting you for file name. Search for the file you want and select it. The user can also select the playback rate.



Select Stop Playback to cease playback of the encoder data stream. Pause/Resume functionality also exists for this feature.

FILE FORMAT

Saving Encoder data to a file results in a Big-Endian formatted binary file containing all information received from the Encoder Test Box. This file contains a series of packets, each packet containing the Host Command Word sent and the Encoder Output Word received. Each packet consists of 14 bytes (for AIME-II & ARA) or 8 bytes (for TRACKER & MKE). The first 4 bytes contain the Host Command Word with the following bytes containing the Encoder Output Word. Each part is justified to the most significant bit within the field.

	Host Command Word				Encoder Output Word									
Byte #	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Ex. Data (hex)	7F	FF	FF	FF	2C	99	6F	CF	00	51	E4	26	CD	C0
Ex. Meaning	Normal Command				Encoder Position				Status		Diag	CRC		Rsvd

Table 1: AIME-II & ARA File Format

	Host Command Word				Encoder Output Word			
Byte #	1	2	3	4	5	6	7	8
Ex. Data (hex)	00	00	00	00	2C	99	6F	CF
Ex. Meaning	Normal Command				Encoder Position/Status			

Table 2: TRACKER & MKE File Format

See MM-248 nanoSeries® AIME-II Communications Protocol or MM-253 nanoSeries® TRACKER SPI Communications Protocol for more information on the Host Command and Encoder Output Words.